DOCUMENT RESUME

ED 383 542 SE 056 130

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TITLE The Effects of a Peer Tutoring Program on Math Fact Recall and Generalization.
PUB DATE Aug 94
NOTE 27p.; Paper presented at the Annual Meeting of the American Psychological Association (Los Angeles, CA, August 1994).
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Arithmetic; *Elementary School Students; Grade 4; Grade 5; Intermediate Grades; Mathematics Education; Mathematics Skills; *Memorization; *Multiplication; *Peer Teaching; *Remedial Instruction; *Tutorial Programs

ABSTRACT

This study used a multiple-baseline-across-subjects design to assess the effectiveness of a peer tutoring intervention for fluency in basic math facts. Specifically, this study assessed the rate of recall of multiplication facts throughout the intervention period and determined whether the progress was matched by improvement in actual classwork. In addition, maintenance of gains in fluency and classwork were assessed. The students targeted were fourth- and fifth-graders (n=8) selected from a combined classroom in an Appalachian elementary school. Children with mild disabilities were included in this classroom. Teacher recommendations along with a multiplication facts probe were used to select tutors and tutees. Baseline data were collected from tutees before intervention occurred. Tutors were trained by the experimenter (3 sessions), then were assigned a tutee. Peer tutoring sessions occurred 2 to 3 times a week for about 15-20 minutes at a time. Data from multiplication fact probes and worksheets indicated: (1) Improvement in fluency occurred for 6 of the 8 students; (2) All students showed some degree of improvement on worksheets during intervention; and (3) The treatment promoted retention over several weeks' time. Results offer some promising preliminary information about the long-term effectiveness of peer tutoring. (Contains 12 references.) (CSO)

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ED 383 542

The Effects of a Peer Tutoring Program on Math Fact Recall and Generalization

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Introduction

In the last 25 years or so, educators have begun taking a second look at peer tutoring as a cost- and time-efficient method of individualizing a child's education. For example, peer tutoring has been used to improve children's word recognition (Chiang, Thorpe, & Darch, 1980), spelling (Delquadri, Greenwood, Stretton, & Hall, 1983), math (Sharpley, Irvine, & Sharpley, 1983), and written capitalization (Campbell, Brady, & Linehan, 1991).

Teachers are sometimes reluctant to use peer-influenced learning methods because the teacher's role in peer-assisted learning is no longer that of the chief source of information and instruction (Aronson & Goode, 1980; Moskowitz, Malvin, Schaeffer, & Schaps, 1983). It is important, then, to demonstrate the ease and the effectiveness of such programs so that these teachers may be willing to try them.

The purpose of this study was to assess the effectiveness of a peer tutoring intervention for fluency in basic math facts. Specifically, the study assessed the rate of recall of multiplication facts throughout the intervention period and determined whether the progress was matched by improvement in actual classwork (generalization effect). In addition, maintenance of gains in fluency and classwork were assessed. The students targeted were fourth- and fifth-graders, ages 9 to 11, in

a rural Appalachian elementary school. Students identified as having disabilities as well as general education students were included.

Method

Subjects were selected from a combined fourth- and fifth-grade classroom in a rural Appalachian elementary school. Children with mild disabilities were fully included in this classroom. The teachers had previously taught all multiplication fact families and had moved on to double-digit multiplication. A multiplication facts probe was administered by the experimenter to the entire class in order to identify students experiencing difficulty with multiplication fact fluency as well as those who had attained mastery of facts. Probe results and teacher recommendation were used in combination to select tutors and tutees. These students were a mixture of non-identified students and those identified as having learning disabilities (LD) and educable mental disabilities (EMD). Participation was voluntary, with parental permission.

Materials. Six alternate forms of a multiplication facts probe were developed and used. Each probe contained 50 multiplication fact problems, using factors 1 through 9, with even distribution of all facts. Probes were administered either two or three times weekly.

A recording form in which the tutor logged the number of facts mastered during each session also was kept inside the

tutee's tutoring folder. A reinforcement chart with 12 spaces was provided. The tutee kept track of progress toward the reward by marking off a space for each fact mastered. When a reinforcement chart was completed, the reward was provided and a new chart was begun. The reward was selected from a menu of desirable trinkets (e.g., pencils, erasers, stickers, candy) previously developed through a poll of student preferences.

A work mat (a paper mat with spaces marked for organizing the different sets of flashcards) also was provided for the use of the tutor. This folder had pockets for storing the different groups of cards.

Teachers assigned multiplication worksheets (previously selected from published workbooks provided by the experimenter) twice weekly. These worksheets contained only simple multiplication problems and included at least two fact families. From 25 to 100 problems were on each worksheet.

Dependent measures. There were three dependent measures: (a) correct rate of multiplication fact recall, measured by timed performances on the 50-item probes; (b) error rate of multiplication fact recall, also measured by timed performances on the 50-item probes; (c) percent accuracy on math worksheets.

Multiplication worksheets were given to the students during the regular math period by the teachers in the classroom. The teachers handed out the page to all of the tutored students (who

were all in the same math group) and told them to answer the ones they knew and to mark an X on the ones they did not know. After five minutes, the teacher collected the sheets.

Procedures. A probe containing all facts (100 facts, using factors 1 through 10) was administered to all tutees in order to ascertain which facts had been learned and which had not. This information was used to prepare flashcards which were divided into two groups. Those which were previously learned were marked with a green dot; those which were not yet learned were marked with a red dot. The first ten cards to be drilled were prepared for each tutee, using a proportionate mixture of 30% unlearned to 70% learned facts, as recommended for optimum success in previous studies (Dickinson & Butt, 1989; Gickling & Armstrong, 1978). These ten cards were called the drill set.

Tutor training. Tutors were trained by the experimenter during three sessions (one 30-minutes, two 40-minutes). All tutors were trained at the same time, in early March. Modeling and role-playing were the major methods of instruction. Tutors were assessed individually by the experimenter for readiness during the third training session, and were considered ready to begin tutoring when, during role-play with other tutors, they correctly performed 100% of the tasks on a procedural reliability checklist.

Design. A multiple-baseline across subjects was employed to

assess the effects of the tutoring intervention upon multiplication fact error rate and generalization to math worksheets. Three multiple baselines were used, two with three students, and one with two students. The first triad included three non-identified students. The second triad included three students who had been identified LD. The third group included two students identified EMD; one of these had a secondary diagnosis of behavior disordered (BD). Baseline data were collected for one and one-half weeks (four probe data points, three worksheet data points) prior to implementation of the intervention for three tutees. Progressively longer baselines were extended for the rest of the tutees; for each group, the next tutee began tutoring when the previous tutee had shown a definite positive change in level or trend (at least seven data points) on the probes. The order in which students began tutoring was determined randomly.

Baseline. During this phase, which occurred in late February and early March, no peer tutoring was administered. Math worksheets by the tutees were assigned and collected by the teachers in the classroom twice weekly and placed in folders after checking. In addition, alternating forms of the multiplication facts probe were administered twice weekly to each tutee by the experimenter, in order to determine the pre-intervention fluency level of each tutee. Throughout the study, probes were administered in the stairwell outside of the classroom.

Tutoring. The tutoring procedure was adapted from that developed for sight words by Murphy and Fasko (1990), using recommendations for flashcard drill developed by Van Houten and Rolider (1989). Throughout the tutoring phase, multiplication fact probes continued to be given two or three times weekly. Each tutoring session lasted about 20 minutes each day.

Tutoring began with Students 1, 4, and 7 in late March. Tutors began by opening out the work mat and the flash cards. The previously learned cards had a green dot; the unlearned cards had a red dot. These decks were called the red and green decks, and they were stored in the corresponding pockets on the work mat. The tutor took the previously prepared drill set. The drill cards were shown one by one to the tutee, who had three seconds to respond correctly by reading the entire problem and answer.

If the answer given was correct, the tutor confirmed this by saying "That's right!" or "Good!," placed the card on the spot marked "Correct," and went on to the next card. If an incorrect answer was given, the tutor said "No," in a firm voice, stated the problem and the correct answer, and had the tutee repeat it. The tutee confirmed it if correct. The card was then marked on the back with an X and placed behind the next card in the drill deck, and the tutor then went on to the next card.

After all 10 cards were shown (and any repeats), the tutor

marked an O on the back of those cards that were identified correctly within the time limit. The cards were shuffled and the procedure was repeated with the same ten cards. At the end of the session, a line was drawn under the X's and O's to separate each day's marks. When a card had at least five O's in a row on the back and going across two days, it was considered mastered. The card was then placed on the spot marked "mastered" and replaced with a new card from either the red or the green deck, depending on the type of card mastered, thus retaining the ratio of learned to unlearned facts.

At the end of each session, which lasted about 15 minutes, the number of mastered cards were counted and recorded by the tutor on the recording form, and the tutee recorded the corresponding number of marks on the reinforcement chart. When the 12 spaces of the reinforcement chart were completed, the tutee was allowed to select a reward from the reward box, and a new reinforcement chart was started. At the end of each session, each group of cards (the new deck, the drill deck, and the mastered deck) were put away in the appropriate pocket in the tutee's folder. At the beginning of the next and all subsequent sessions, the previously mastered cards were reviewed and verbal feedback given by the tutor. If the tutee missed one of the mastered facts, an X was marked on the back, the student was corrected, and the card was placed behind the next card. At the end of the

review, all cards identified correctly were marked with an O. When a mastered fact was identified correctly in review three days in a row (identified by three Os) the card was retired and no longer reviewed. The tutor then began again with the same drill deck as the previous session, and the Os and Xs already on these cards were carried over. The peer tutoring phase for each tutee continued until all facts were mastered or, as in the case of one Student 3, the school year ended.

Student 2's intervention phase was interrupted when it became apparent that although he was mastering facts orally with his tutor, he was not showing any improvement on the written probes. Because of this, it was decided to modify his intervention to provide practice in transferring his responses to paper.

During the probes, Student 2 , said such distractors as, "Hurry, hurry!" "Oh, oh, I know this one, what is it?" It was decided to attempt to teach Student 2 the strategy of whispering the facts to himself before writing them. Tutoring was withdrawn for eight school days. Training was then begun to modify Student 2's self-talk during probes. Student 2's tutor used blank probes and instructed him to say aloud the problem and its answer, then write it down. If Student 2 could not orally complete the problem after 3 seconds, the tutor supplied the answer and instructed him to write it down. For every ten problems completed without assistance, Student 2 was allowed to mark off one space on his

reinforcement chart. This modified intervention was continued until the end of the school year.

Maintenance. For the remainder of the school year following the intervention phase for each dyad, each tutee continued to receive multiplication facts probes twice weekly to determine whether the student had maintained the same performance level. In addition, the teachers continued to collect worksheets on these students.

Results and Discussion

Data from multiplication fact probes and math worksheets were collected by the experimenter and recorded on graphs. Measures of reliability and procedural reliability were conducted throughout the three phases of the study.

Correct and error rates for the fluency probes and worksheets are shown in Figures 1 through 6. Means, medians, and standard deviations for each phase are shown in Tables 1 through 3. A summary of results is shown in Table 4.

Insert Figures 1 to 6 about here

The results indicated a definite improvement in fluency for six of the eight students (i.e., all of the students in the two mild disabilities groups, and one student in the nonidentified group) after initiation of the intervention, and a seventh student

(Student 2) showed improvement after the intervention was modified. Student 2 was later referred for assessment to determine eligibility for special education services, and qualified for learning disabled services because of significant difficulties with written expression. This difficulty with written expression may contribute to his difficulties with writing the correct facts even when he was able to verbally identify them. When the intervention was modified to allow him to whisper the fact to himself before writing it, his correct rate increased by 26% over baseline and his error rate decreased by 57%.

Insert Tables 1 to 4 about here

Two of the six (Student 6 in the group identified for learning disability services and Student 7 in the group identified for educable mental disabities services) improved their fluency mainly by decreasing their error rate. Student 6's error rate fell steadily during the intervention phase. Student 7's error rate was quite variable during the intervention but by the end of this phase his error rate was significantly lower. Student 1, in the nonidentified group, improved her rate by increasing her correct rate. Student 1's error rate was already fairly low. During the intervention and maintenance her error rate decreased even more (by 75%), and her correct rate improved dramatically

(83%).

The final student, Student 3 in the nonidentified group, had less variable performance during the intervention; both his correct rate and his error rate increased. Student 3 had truancy problems during the spring, averaging about one absence per week. It may reasonably be assumed that he did not master all of his facts before the end of school because of this absenteeism.

Thus, this study appears to confirm the work of the Juniper Gardens project and others (e.g., Trovato & Bucher, 1980; Salend & Nowak, 1988) which indicates that peer tutoring is an effective method for academic skills instruction. Like the Classwide Peer Tutoring studies, this peer tutoring program featured frequent opportunities to respond. An examination of number of trials required for each student to achieve mastery revealed that student averages ranged from 7.2 to 16.0 trials. It is unlikely that these students would have this much opportunity to respond during traditional teacher-led instruction. Thus, the results suggest that this method of improving multiplication fact fluency may be effective for students who did not master facts through teacher instruction alone.

All of the students showed some degree of improvement on worksheets during the intervention (or, as in Student 2's case, during the revised intervention). Student 1, in the nonidentified group, and Student 7, in the group identified for educable mental

disabities services, demonstrated significant gains in worksheet performance accuracy. Student 6, in the group identified for learning disability services, while variable, began a definite upward trend during the intervention. Student 8's (in the group identified for educable mental disabities services) accuracy improved slightly during the intervention. Student 2 (nonidentified group) appeared to be gaining somewhat during his modified intervention phase.

Interestingly, it appears that Student 3's worksheets began to improve during the intervention (although only four data points were available for analysis). This improvement occurred in spite of a lack of clear improvement in the fluency probes. It is possible that Student 3 actually was improving his fluency but was not motivated to perform on the probes for the examiner; he may have perceived the work assigned by his teacher (who had the power to retain him) to be more worth his effort.

Student 4 and Student 5, in the group identified for learning disability services, demonstrated only slight improvement on their worksheets during the intervention, although both had shown improvement on their fluency probes, suggesting that they may not have been motivated to be accurate on worksheets. Perhaps a reinforcement program built into worksheet accuracy may have been helpful.

It is important to note that one worksheet yielded an

elevated score for all eight students. An examination of this worksheet revealed that, although there was a mixture of factors, almost all were combinations of the smaller numbers (2, 3, and 4 times one another). There was only one fact containing 9 as a factor, 3 with 7 as a factor, and 2 with 8 as a factor, but these were all combined with small digits. This may explain the relatively high scores for all students on this worksheet. When taken within this context, the improvements of the two students in the EMD group (Group 3) are quite impressive.

Maintenance of fluency and worksheet performance was assessed in this study for five of the eight students, whose maintenance periods ranged from two to six weeks. Student 3 and Student 2 did not have a maintenance period, and Student 6's maintenance period was too brief (one week) for analysis. All of the students who made gains on fluency or worksheet performance sustained those gains during maintenance; those who did not have gains in those areas did not lose any ground ground during maintenance. Thus it appears that this peer tutoring program promoted retention over several weeks' time of the skills learned. This particular aspect of peer tutoring was not addressed in the studies reviewed for this investigation. The results of this study offer some promising preliminary information about the long-term effectiveness of peer tutoring.

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FIGURE 1
Group 1 Probes

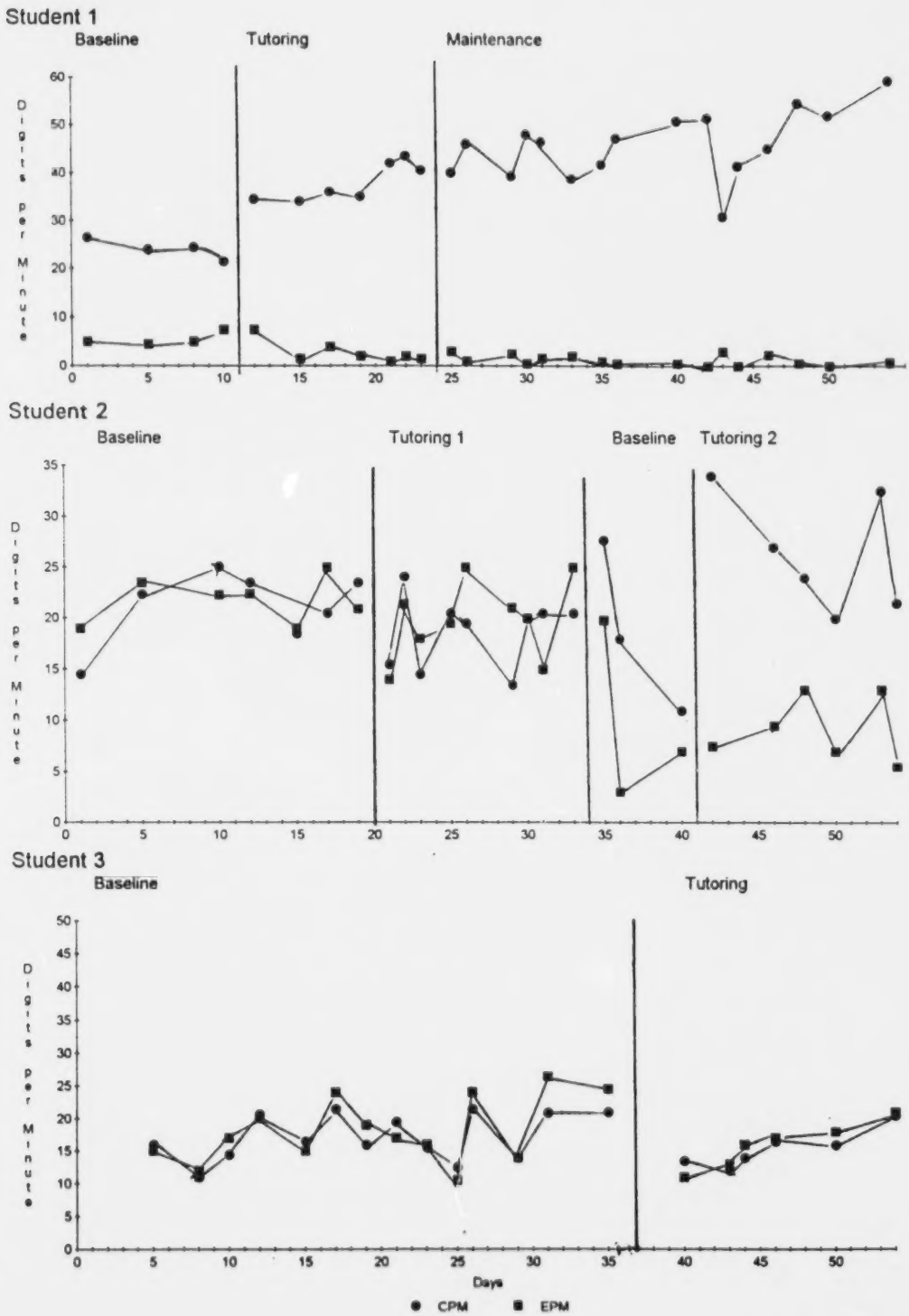
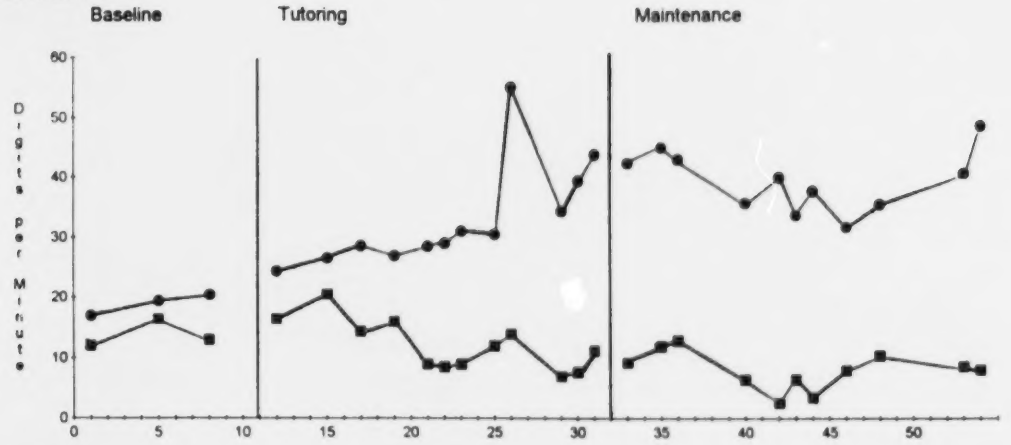
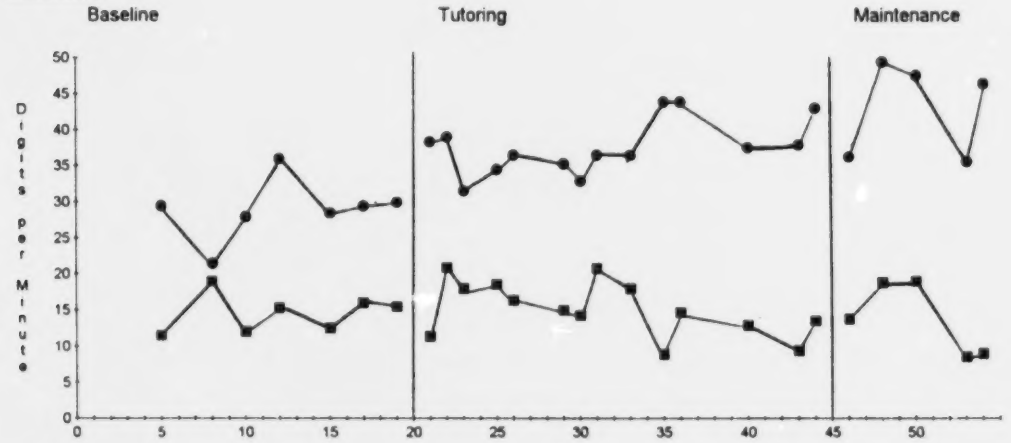


FIGURE 2
Group 2 Probes
Student 4



Student 5



Student 6

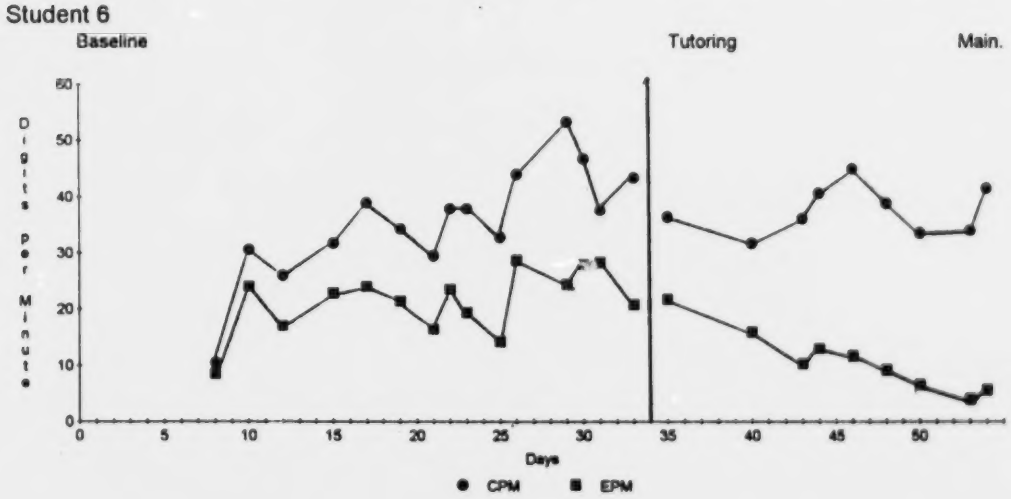
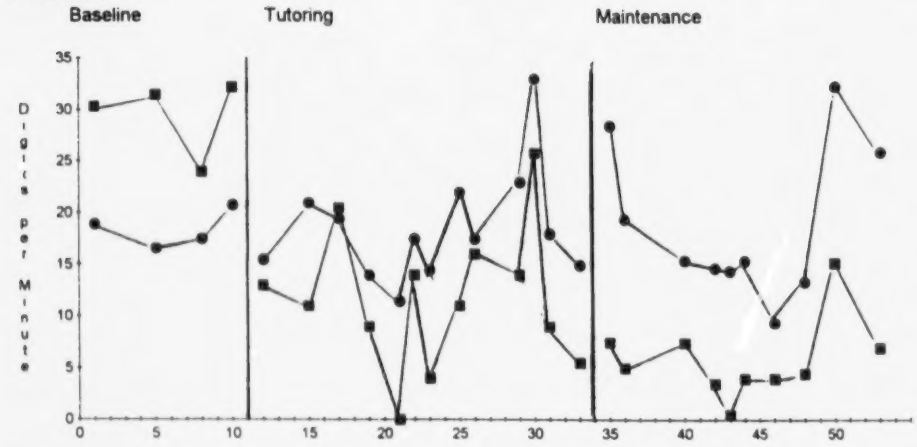


FIGURE 3

Group 3 Probes

Student 7



Student 8

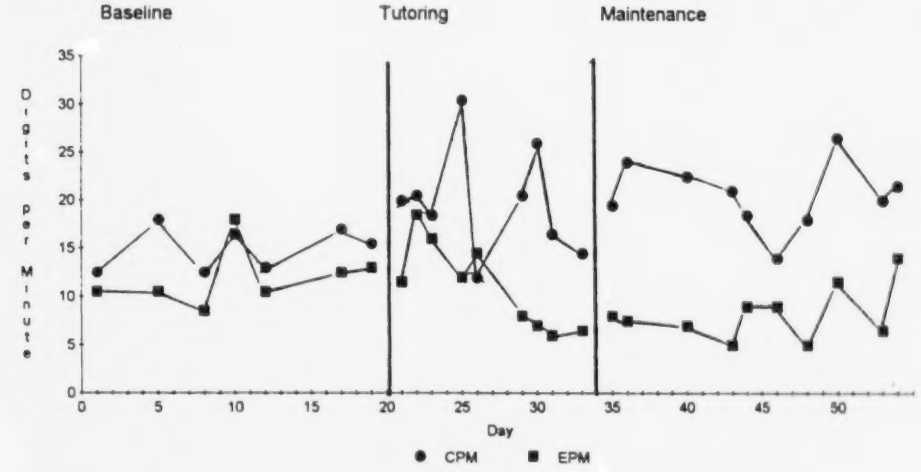


FIGURE 4
Group 1 Worksheets

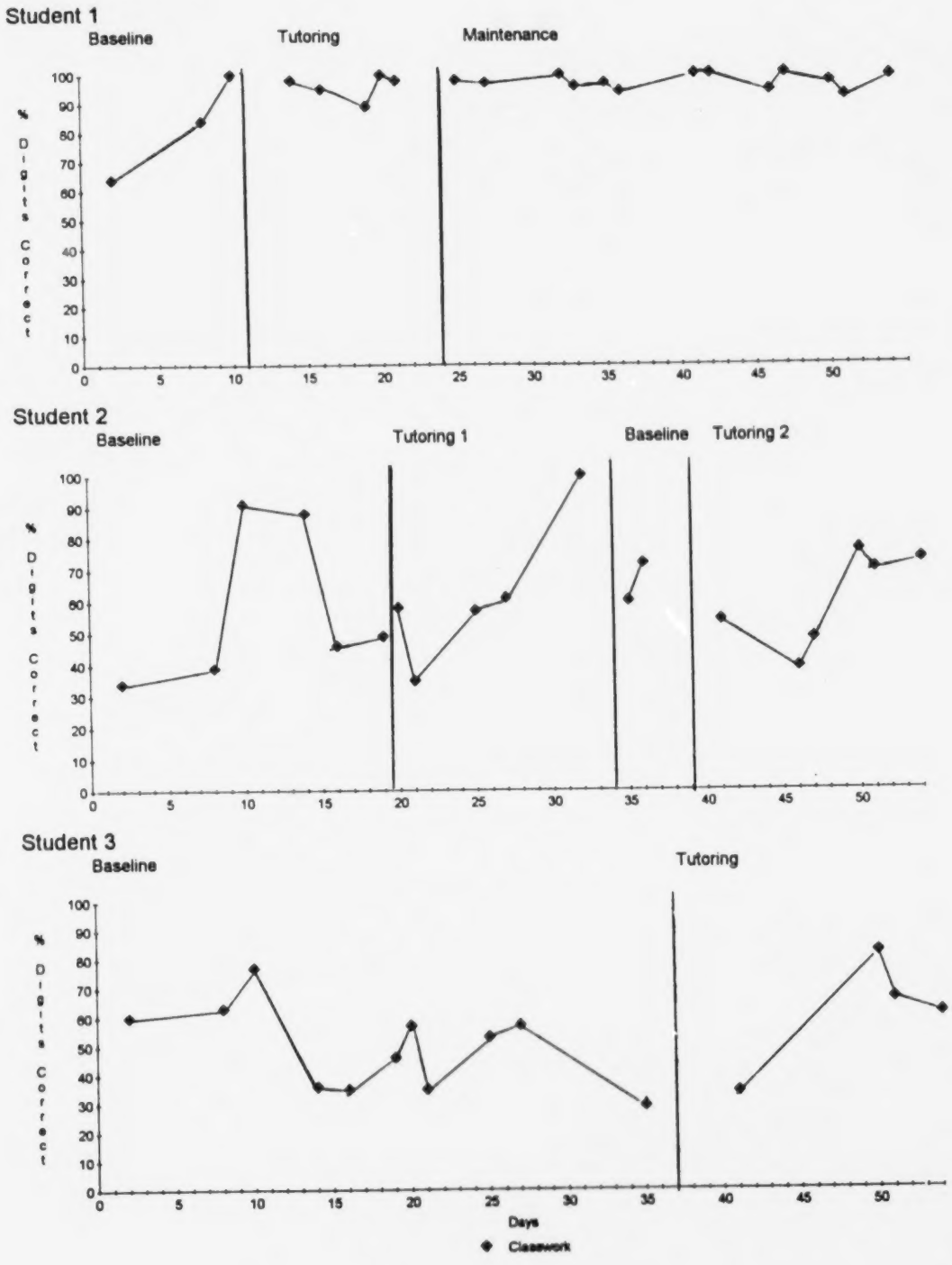
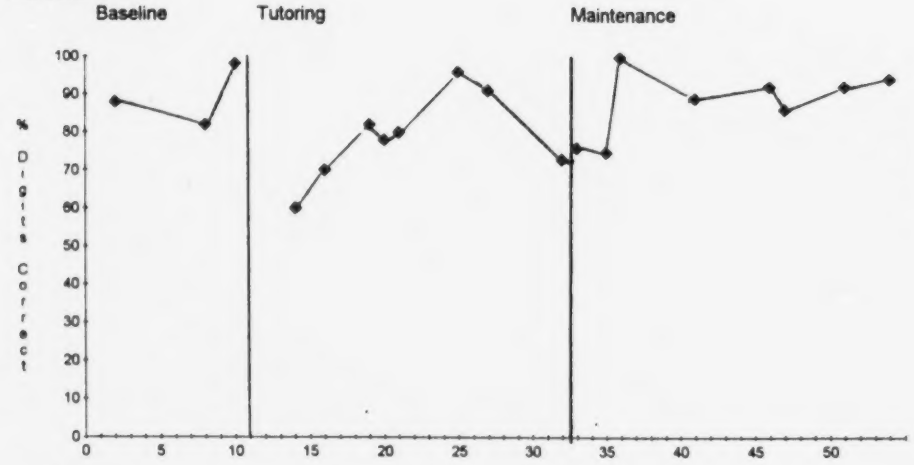
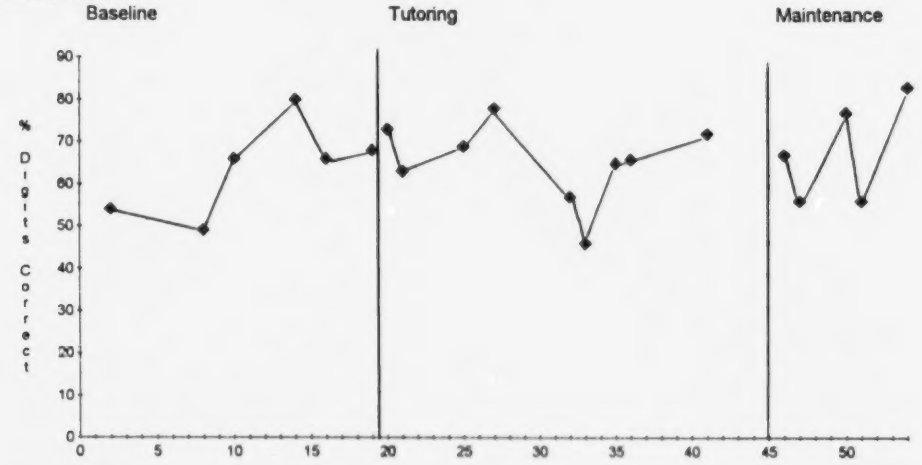


FIGURE 5
Group 2 Worksheets

Student 4



Student 5



Student 6

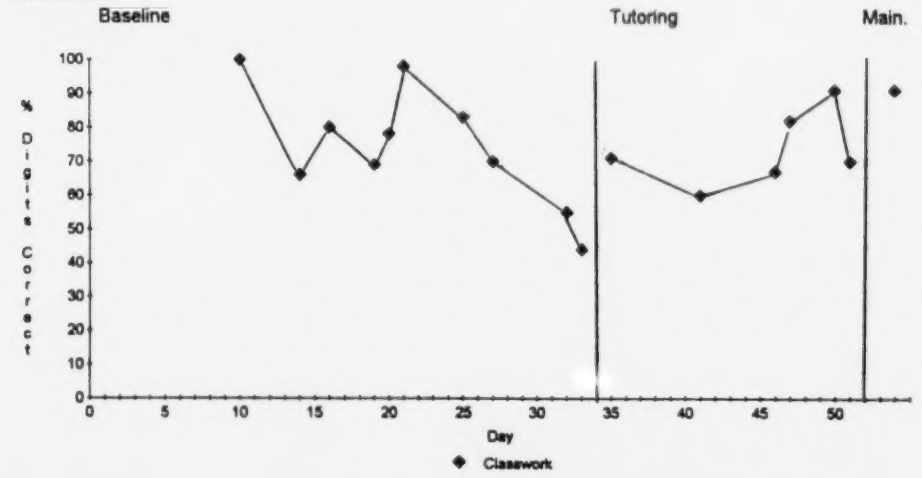
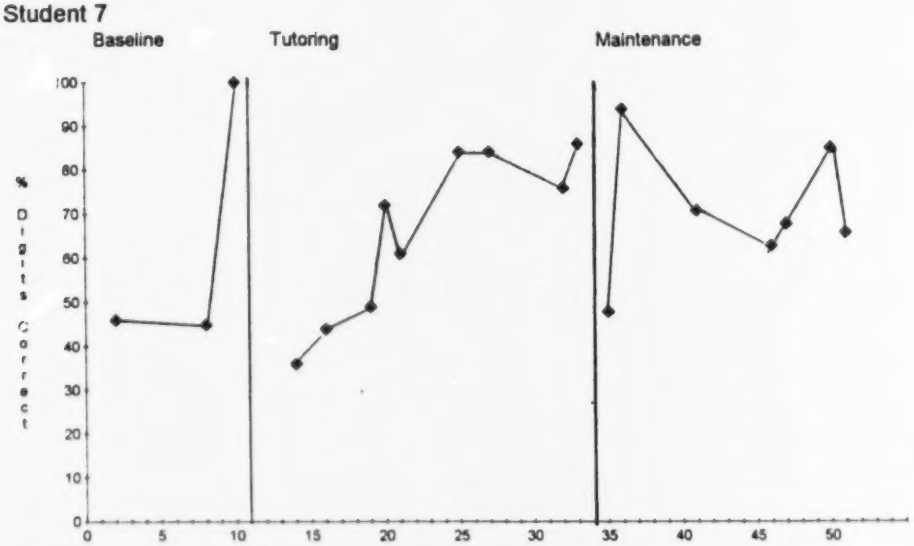


FIGURE 6
Group 3 Worksheets

Student 7



Student 8

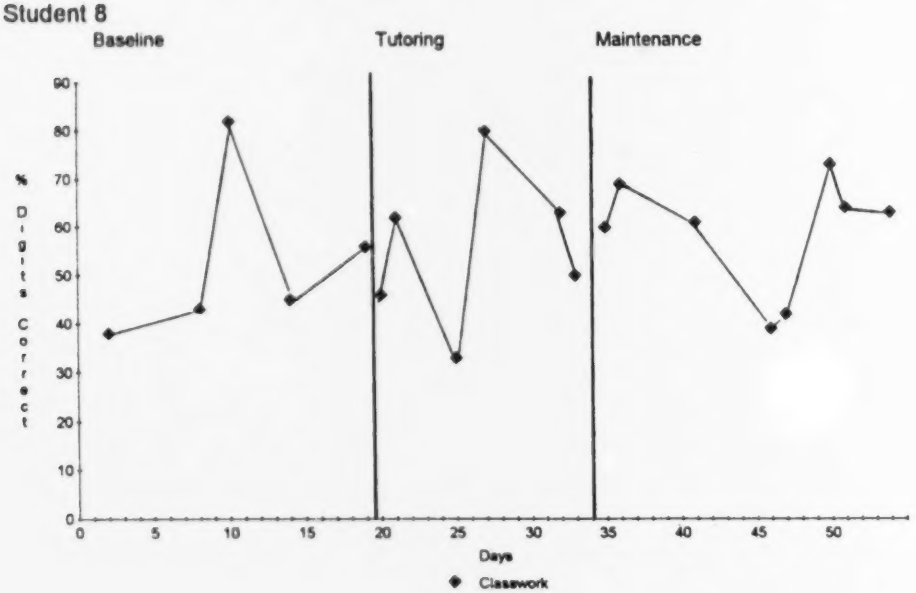


TABLE 1
Group 1:
Means, Medians, & Standard Deviations for Probes & Worksheets

	Phase	Variable	Mean	Median	S.D.
Student #1	Baseline	CPM	24.1	24.3	1.78
		EPM	4.8	5.0	0.24
		Classwork	82.7	84.0	14.70
	Tutoring	CPM	37.9	36.0	3.66
		EPM	2.8	2.0	2.12
		Classwork	96.0	98.0	3.85
	Maintenance	CPM	44.0	46.4	11.16
		EPM	1.2	0.9	1.02
		Classwork	97.2	97.0	2.55
Student #2	Baseline	CPM	21.1	22.4	3.38
		EPM	21.7	22.3	2.08
		Classwork	57.8	47.5	22.90
	Tutoring 1	CPM	18.7	20.0	3.27
		EPM	19.9	20.0	3.62
		Classwork	52.8	57.5	10.35
	Baseline 2	CPM	18.9	18.0	6.84
		EPM	9.9	7.0	7.17
		Classwork	66.0	66.0	6.00
	Tutoring 2	CPM	26.5	25.5	5.26
		EPM	9.3	8.5	3.00
		Classwork	60.0	62.0	13.82
Student #3	Baseline	CPM	17.2	18.0	3.45
		EPM	18.2	17.0	4.79
		Classwork	49.8	53.0	14.17
	Tutoring	CPM	15.4	15.0	2.73
		EPM	16.0	16.5	3.27
		Classwork	60.8	63.5	17.28

TABLE 2
Group 2:
Means, Medians, & Standard Deviations for Probes and Worksheets

	Phase	Variable	Mean	Median	S.D.
Student #4	Baseline	CPM	19.0	19.5	1.47
		EPM	13.8	13.0	1.92
		Classwork	89.3	88.0	6.60
	Tutoring	CPM	33.3	29.8	8.50
		EPM	12.2	11.7	4.02
		Classwork	78.8	79.0	10.73
	Maintenance	CPM	39.7	40.3	4.88
		EPM	8.1	8.1	3.06
		Classwork	88.0	90.5	8.14
Student #5	Baseline	CPM	29.0	29.5	3.93
		EPM	14.5	15.3	2.49
		Classwork	63.8	66.0	10.04
	Tutoring	CPM	37.8	36.6	3.67
		EPM	15.2	14.9	3.68
		Classwork	58.8	66.0	20.71
	Maintenance	CPM	43.1	46.5	5.92
		EPM	13.8	13.8	4.54
		Classwork	67.8	67.0	10.91
Student #6	Baseline	CPM	35.7	37.6	9.69
		EPM	21.3	23.5	5.48
		Classwork	63.3	70.0	24.55
	Tutoring	CPM	37.5	36.4	4.15
		EPM	12.5	11.6	4.62
		Classwork	73.5	70.5	10.18
	Maintenance	CPM	37.8	37.8	3.75
		EPM	4.8	4.8	0.80
		Classwork	91.0		

TABLE 3
Group 3
Means, Medians, & Standard Deviations for Probes & Worksheets

	Phase	Variable	Mean	Median	S.D.
Student #7	Baseline	CPM	18.5	17.1	1.59
		EPM	29.5	30.9	3.23
		Classwork	63.7	46.0	25.69
	Tutoring	CPM	18.6	17.5	5.25
		EPM	11.8	11.0	6.55
		Classwork	65.8	72.0	17.89
	Maintenance	CPM	19.0	15.5	7.07
		EPM	5.9	4.8	3.74
		Classwork	70.7	68.0	13.89
Student #8	Baseline	CPM	15.0	15.5	2.14
		EPM	11.9	10.5	2.83
		Classwork	52.8	45.0	15.74
	Tutoring	CPM	19.9	20.0	5.33
		EPM	11.1	11.5	4.28
		Classwork	58.7	57.5	12.72
	Maintenance	CPM	20.5	20.5	3.57
		EPM	8.3	7.8	2.67
		Classwork	58.9	62.0	11.35

TABLE 4

Summary of Results

	Services	Fact Fluency	Math Work
Student 1	None	Improved significantly Maintained gains	Improved; Maintained gains
Student 2	None; later LD	Slight Improvement after intervention modified; no maintenance period	No improvement; No maintenance period
Student 3	None	No improvement; No maintenance period	Improved; No maintenance period
Student 4	LD	Improved significantly; Maintained gains	No improvement; Maintenance scores stable
Student 5	LD	Improved; Maintained gains	Fell slightly; rose during maintenance period
Student 6	LD	Improved considerably; No maintenance period	Improved slightly; No maintenance period
Student 7	EMD	Improved significantly; Maintained gains	Improved significantly; Maintained gains
Student 8	EMD	Improved considerably Maintained gains	Improved ; Maintained gains